# Diversity and abundance of ground-dwelling ferns over a tropical montane moisture gradient at Monteverde, Costa Rica

Zoë M. McLaren

*Abstract:* The distribution of a species is dependent on its ability to disperse and reproduce in different habitats. Fern species are relatively abundant in the montane cloud forest of Monteverde, Costa Rica due to high water availability. I hypothesized that a moisture gradient occurring over the elevational range of 1350 to 1750 m would affect fern diversity and abundance. Specifically, I predicted that there would be greater diversity and abundance in wetter, high elevation habitats. Sites at 1350, 1550 and 1750 m elevation corresponded to low, medium and high moisture gradients. Twenty 5 x 1 m transects were randomly sampled for fern morphospecies abundance, size and diversity in each site. Species diversity and evenness increased as moisture level increased. Fern biomass was lowest at the low moisture site, and peaked at the mid-moisture level site. Fern abundance (individuals/$m^2$) increased with moisture level. Aggregation of individuals decreased with increasing moisture level. My results support the hypothesis that fern diversity and abundance are affected by the altitudinal moisture gradient. If the present climatic patterns of increasing warmth and dryness at Monteverde continue, fern diversity and abundance may be reduced.

*Key Words: dispersal, free water, reproduction*

## Introduction

The distribution and abundance of a species is dependent on that species' ability to disperse and reproduce in a range of habitats. The reproduction and dispersal of ferns is dependent on the availability of free water, both to disperse the spores, and through which the sperm can swim to cross-fertilize the eggs (Wagner and Gomez 1983). The cloud forest of Monteverde, Costa Rica, is located within a regional center of tropical American fern diversity, probably due to abundant moisture (Tryon 1972). Although ground-dwelling ferns are a significant part of terrestrial plant diversity in the area, few studies have focused on these species.

A previous study found that tree fern diversity increased with the elevational moisture gradient at Monteverde (Lee et al. 1986). I hypothesized that this moisture gradient would also affect the diversity and abundance of ground-dwelling ferns. If so, I would expect to find a greater diversity and abundance of ground-dwelling ferns in high-elevation habitats containing more moisture.

## Methods

Three primary forest sites were selected at three different elevations along the Pacific slope of the Cordillera Tilarán in the vicinity of Monteverde, Costa Rica: a low elevation site (1350 m), a mid-elevation site (1550 m), and a high elevation site (1750 m). These sites correspond to a moisture gradient running from low moisture at low elevation to high moisture at high elevation. In each site, fern abundance and diversity was recorded in 20 randomly-placed, non-overlapping transects (5 x 1 m) along the available trail system. Transects ran parallel to and uphill of the trail. For each cluster of ferns (one individual) within the transect, I recorded the number and size of fronds. Individuals were classified to morphospecies.

Individual biomass was estimated by grouping fronds into 3 size classes, and multiplying the number of fronds in each size class by half the average frond length of that size class. A dispersion index was calculated as the variance in species abundance among transects divided by the mean abundance of a species at a site.





## Results

Morphospecies richness of ground ferns increased with moisture level across the sites: only 1 morphospecies was found in the low moisture site while 8 morphospecies were found in the high moisture site (Fig 1). Total fern biomass (per $m^2$) was the lowest in the low moisture site and increased two-fold to the maximum value in the mid-elevation site (Fig 2). Dispersion analyses showed ferns to be more aggregated at the low-elevation site (Table 1).

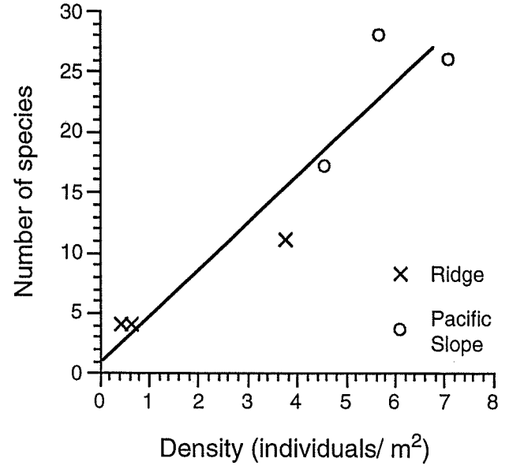


Figure 1. The relationship between density of woody plants and total number of morphospecies in gaps on the Pacific slope and near the ridge top.

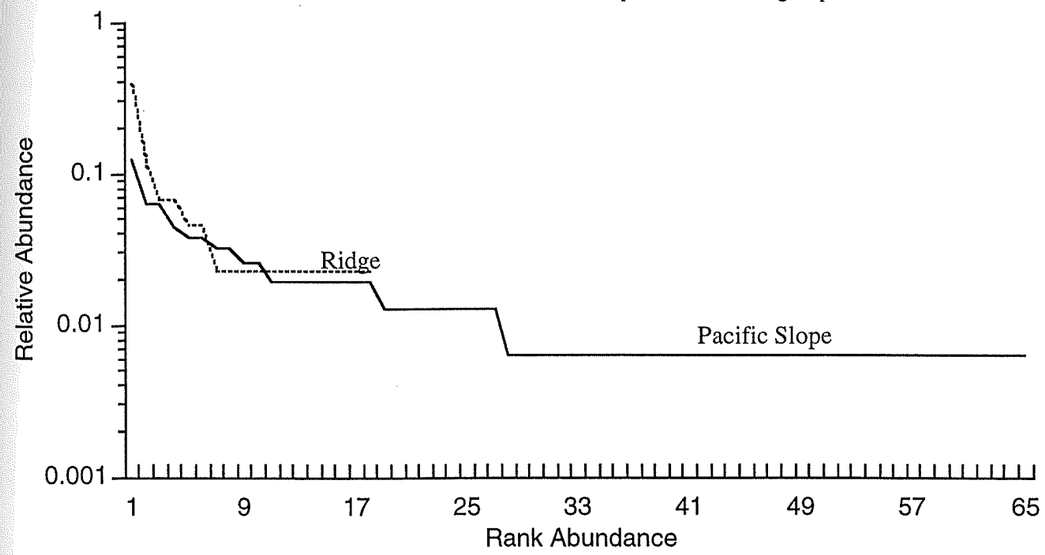


Figure 2. Ranked abundance of woody plant morphospecies in treefall gaps from two elevation zones of the Monteverde cloud forest, Costa Rica.

## Discussion

The increase in ground fern diversity with moisture level may be explained by the availability of free water in the environment that facilitates both dispersal and reproduction of fern species. Diversity in low moisture environments may likewise be limited by the inability of many species to meet this ecological challenge of low water availability. The fronds of the one species found in the low moisture site were thicker and more leathery

Table 1. Index of Dispersion (variance / mean) for most common fern species at three sites along an elevational moisture gradient in Monteverde, Costa Rica. High index values indicate more aggregated fern distribution.

| Moisture Level | Dominant Species | Index of Dispersion |
|---|---|---|
| Low | Morph 1 | 10.37 |
| Mid | Morph 3 | 9.85 |
| Mid | Morph 1 | 2.84 |
| High | Morph 3 | 6.80 |
| High | Morph 7 | 5.12 |
| High | Morph 8 | 5.90 |

than those of morphospecies found in the mid and high moisture sites. This frond structure is likely an adaptation to reduce water loss in the low moisture environment.

The increase in biomass between low and mid elevation sites may also be explained by the increase in free water for dispersal and growth. Free water in the mid elevation site allows each species to disperse to more suitable habitats and to grow at a higher rate than in the low elevation site, thus increasing the biomass. Although moisture levels increase in the high elevation site, fern biomass is reduced relative to mid-elevation. This may be attributable to competition from the herbaceous plants that become very abundant on the forest floor at high elevation.

Fern individuals were more clumped in the low moisture site than the mid or high moisture sites, which may also be explained by the lack of moisture for reproduction and dispersal. This is consistent with the observation that many microhabitats at the low-elevation site that were apparently suitable for fern growth (e.g. abundant moist, dead wood), had no ferns within or around them. This difference in dispersion was not due to the attributes of the species that occupied the lower site because the same species exhibited a less-clumped dispersion in the mid-elevation site. Clusters of ferns in all three sites were often monospecific, which suggests that the initially colonizing species maintained an advantage in additional growth and dispersal. Future studies could investigate how the presence of an adult conspecific or inter-specific affects the colonization and growth of juvenile ferns.

My observations indicated that ferns were more abundant than other plants in highly sloped areas at all sites. This may be a result of their method of reproduction and morphology. Ferns may be able to colonize an incline best because the water flow along the slope transports gametes for reproduction and dispersal. Additionally, the low weight of the fronds and the elaborate root structure might allow ferns to maintain a hold on a steep slope more easily than woody plants. Apparently, reproduction, dispersal and/or competitive interactions tend to favor ferns relative to herbaceous plants more on slopes than on level ground.

Recent warm and dry climatic patterns at Monteverde have apparently affected the distribution of many species (Pounds et al. 1999). The associated reduction in free-water availability may also reduce local fern diversity and abundance. My study provides a first step in documenting altitudinal patterns in the diversity of ferns. My results indicate that the distribution and abundance of ground-dwelling ferns is dependent on water availability, which





suggests that climate changes may have impacts on the many endemic ground-dwelling ferns of the Monteverde cloud forest (Tryon 1972).

## Literature Cited

Lee, M.A.B. et al. 1986. The distribution of tree ferns along an altitudinal gradient in Monteverde, Costa Rica. Brenesia 25/26: 45-50.

Pounds, J. Alan, J.A. Fogden, M.P.L. Campbell. 1999. Biological response to climate change on a tropical mountain. Nature 398: 611-15.

Tryon, R. 1972. Endemic areas and geographic speciation in tropical American ferns. Biotropica 4: 121-131.

Wagner, W.H. and L.D. Gomez. 1983. *Pteridophytes*. Pp. 311-18 *in* D.H. Janzen editor. Costa Rican Natural History. University of Chicago Press, Chicago, IL.